

MODE OF OPERATION OF A MOVING CELLULAR RADIO NETWORK

This invention concerns mode of operation of a moving cellular radio network. More particularly it includes mode of operation and design of a wireless radio network onboard a vessel. A radio network will serve a wireless handsets and cellular phones of passengers as well as of crew onboard the vessels. The mode of operation insures that, regardless of where the vessel sails, the onboard radio network will never interfere with other radio networks in the vessel's vicinity. Although a passenger ship is used as an example, the vessel can be any kind of vessel. The radio network can be of any type, including spread spectrum networks like Code-Division Multiple-Access (CDMA) or Wideband Code-Division Multiple-Access (WCDMA). However, the example describes a GSM (Global System for Mobile telecommunications) network with frequency adaptability. In spread spectrum systems the frequency adaptability will be replaced by a code- or other suitable adaptability.

Up to now it has not been possible to use mobile or cellular phones onboard ships moving beyond the service area boundaries of national land based radio networks. If currently available systems were to be installed on vessels without modification, these would infringe the frequencies assigned to the national Public Land Mobile networks (PLMNs.)

Systems for public land mobile networks have up to now been stationary. Each operator of such a radio network in a given geographical area, e.g. a country, is assigned certain frequencies different from the frequencies assigned to other operators in the same area so as to avoid interference between these networks.

The installation of a public mobile network onboard a vessel presents an entirely new situation. The onboard radio network will move relative to other radio networks and can move into and out of areas where these other networks operate under licence from local authorities. The operator of an onboard radio network may not be assigned any frequencies from national or local authorities. There is a risk that such a radio network could use frequencies assigned to other networks unless it has the ability to conform to changing surroundings and local regulations. In the case where several vessels carry such a radio network we are faced with a scenario where several such networks move relative to each other. Consequently, in areas without specific regulations or licence agreements these networks are prone to using identical carrier frequencies.

US Patent Application 2002/0072328 describes a mobile infrastructure for wireless communications onboard ships. The mobile infrastructure scans the radio spectrum searching for control channels transmitted by base stations in fixed infrastructures. When a control channel (carrier) is detected, and the mobile infrastructure is within the service area of the fixed infrastructure, the mobile infrastructure will negotiate setting up a direct radio link to the fixed infrastructure. The available frequencies (carriers) will be shared between the two infrastructures, but controlled by the fixed infrastructure. The purpose of that invention is to avoid interfering with fixed infrastructures by avoiding using the

same frequencies in both networks. Furthermore, it aims to reduce ship to shore communications costs by eliminating the use of a satellite link.

US Patent 5867785 describes a mobile infrastructure for wireless communications onboard trains. The mobile infrastructure includes a controller which scans the radio spectrum searching for control channels transmitted by base stations in fixed infrastructures. It then registers with the base station controller in the fixed infrastructure through the base station with the best signal. The base stations in the mobile infrastructure are configured to use different frequencies than those used by the fixed infrastructure. The purpose of that invention is to reduce the amount of signalling during handover. This is achieved by handing over the entire mobile infrastructure rather than the individual cellular phone.

Both of those inventions contains methods for scanning and decoding the control channels transmitted by fixed infrastructures. In US Patent Application 2002/0072328 the decoded information is used to set up a direct connection to the fixed infrastructure on shore thereby avoiding the more costly satellite connection. In US Patent 5867785 the decoded information is used to log on to the base station controller in the fixed infrastructure. Both inventions depend on assigning and sharing the frequency resources controlled by the fixed infrastructure to avoid interference. Both inventions require that the fixed and the mobile infrastructures are parts of the same radio network or that there is a close cooperation between the fixed and mobile infrastructures. To achieve this, new functionality is required in both infrastructures.

US Patent Application 2002/0072328 does not describe how to adapt the mobile infrastructure when control channels from fixed infrastructures are detected. It merely states that de-

tected frequencies shall not be used. Consequently, that solution is not ideal for a ship that repeatedly moves into and out of fixed radio network service areas. Similarly, to avoid interference, US Patent 5867785 takes advantage of the fact that trains move along predefined, known routes and not in a random fashion which ships are likely to do.

Both US Patent Application 2002/0072328 and US Patent 5867785 solve parts of the problem to be solved by this invention.

The purpose of this invention is to reduce one or more of the disadvantages or shortcomings of the known techniques.

This is achieved by using the methods and design as written in the following description and patent claims.

This invention is a method for adapting the radio network to its surrounding frequency environment and frequency regulations.

The invention enables moving wireless telephony infrastructures to dynamically adapt to the surrounding environment by avoiding frequencies occupied by other networks and frequencies for which there is no licence to use. The invention does not require cooperation between the moving radio network and other fixed or moving radio networks.

The method of listening to other infrastructures is a pure spectrum analysis of the relevant frequency bands without demodulating detected signals. In other words, the method employed generates a list of all used frequencies.

A control server controls the radio network by using information from a database about licences and agreements. Together with information from a positioning system, the frequencies that are allowed to be used in a certain area are identified. In addition, the list of used frequencies from the spectrum analysis is used to avoid any conflicts.

Figure 1 depicts a block diagram showing a radio network for mobile communication with corresponding facilities for use onboard vessels. The GSM system is used as an example, but any radio network can be used.

- 5 The system includes the common resources 12 placed on shore (right hand side of figure 1), several remote units called Radio and Control systems 1 installed onboard vessels (left hand side of figure 1), and a satellite link 9, 10, and 11 which connects the remote units with the common resources and
- 10 enables the establishment of communication links to/from public networks 13, public cellular networks 15, and other moving radio networks.

The satellite interface is capable of carrying multiple simultaneous traffic channels in addition to separate signaling channels. The system depicted in figure 1 is one of several possible configurations. Different distributions of equipment between the Radio and Control systems 1 and the common resources 12 is also possible.

The common resources in figure 1 include the central GSM (or alternative spread spectrum technology) functions Mobile Switching Centre (MSC), Visiting Location Register (VLR) and Home Location Register (HLR) 14.

The Radio and Control systems 1 on figure 1 include two parts. The first part is a radio network 2, which enables

25 communication between cellular/mobile phones 16 on the vessel, and ship to shore communication to/from cellular/mobile phones or fixed network phones. The second part includes a control system 3, which controls and dynamically adapts the radio network 2 onboard to the surroundings.

- 30 The radio network 2 on the vessels includes base stations 5 handling the radio communication to and from the cellular/mobile phones 16 and a base station controller 4 that ad-

ministers the base stations 5 and their frequency configuration.

The base station controller 4 on each vessel is connected to a common MSC, VLR, and HLR 14 via the satellite system 9, 10, and 11. Cellular/mobile phones 16 in the radio network 2 can communicate with other public networks 13, public cellular/mobile networks 15, and other moving-radio networks.

Calls between subscribers will be set up using the normal procedures for cellular networks, utilizing the satellite connection to the ship as a transmission path only.

The control system 3 includes a radio sensor 8, a positioning system 6 used to acquire the geographical position of the vessel, and a control server 7 running software to dynamically adapt the radio network 2 of the vessel. The radio sensor 8 could be a normal frequency scanner or spectrum analyzer which scans the frequency bands used for cellular/mobile communications. It is also possible to use the base station equipment 5 for this purpose. For spread spectrum technologies a similar scan and analysis of frequencies and codes must be carried out. The subsequent non-limiting description is based on using a spectrum analyzer.

The main objective of the control system 3 is to adapt the radio network 2 so that it at any given time avoids conflicts with other onboard or land based radio networks, and ensures that operation of the radio network 2 does not infringe the regulations concerning frequency usage of any geographical area the vessel moves into.

The control system uses several methods to adapt to its radio surroundings and the regulations that apply. The control system can reduce the transmitted power so that the signals do not propagate beyond the vessels boundaries, or shut down the radio transmission partly or totally. The control server can

also change the use of base station carrier frequencies to use frequencies where the network is licensed to operate when applicable.

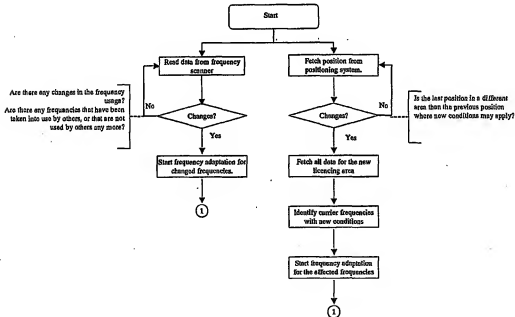
Availability of frequencies in regulated areas can be
5 achieved by obtaining licence to use certain frequencies from the relevant national authorities or by signing agreements with local network operators that already have such licences.

The control system 3 achieves this by using a licence-
database containing information about all given cellular ra-
10 dio frequency licences and regulations in the relevant area, their geographical boundaries and which of these frequencies are available for use by the operator of the radio network on the vessel. The position of the vessel is obtained from the positioning system 6. The position information is used to-
15 gether with the licence database in the control server 7 to decide what conditions are valid at any given time with respect to licences and commercial agreements. The control system also uses the information from the radio sensor 8 which continuously scans the relevant frequency bands in the ves-
20 sel's vicinity. The information about available and occupied frequencies is used to adjust the use of frequencies in the radio network 2.

A non-limiting example of the control server's 7 use of and initial processing of data from the positioning system 6 is
25 illustrated in the right half of the flow chart in diagram 1. At the start of this process, the control server 7 fetches new data from the positioning system 6 and checks whether the new data brings the vessel into a different licensing area. If the vessel moves into a new licensing area, the licence
30 database is checked to see which frequencies are affected by the change. A change may lead to that a different set of frequencies becomes available for the radio network 2.

A non-limiting example of the control server's use of and initial processing of data from the spectrum analyzer 8 is illustrated in the left half of the flow chart in diagram 1. At the start of this process, the control server 7 fetches information from the spectrum analyzer 8 and compares this information to the previous reading to decide whether there have been changes in the used frequencies in the relevant frequency band. The control system will discontinue the use of frequencies in its own radio network 2 if they are detected in the area. Similarly, the control system can make use of frequencies formerly detected as used by others, but have become available in the latest reading.

Diagram 1:



The flow chart in diagram 2 depicts a non-limiting example of how the control server 7 decides which actions to be taken in the case when the conditions from diagram 1 change. The control system will, based on information from the positioning

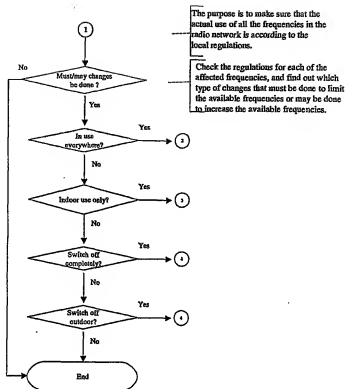
system 6 and the spectrum analyzer 8, decide which carrier frequencies to use and which not to use. This information is compared to the actual use of carrier frequencies in the radio network 2 and poses three possible scenarios:

- 5 Scenario 1: Carrier frequencies become fully or partly available to the radio network 2. Partly available means that the frequency can be used in the parts of the radio network 2 that do not cause signals to propagate outside the vessel.

- 10 Scenario 2: Carrier frequencies must be taken completely or partly out of service from the radio network 2. Partly out of service means that the frequency must be taken out of service from the parts of the radio network 2 that cause signals to propagate outside the vessel.

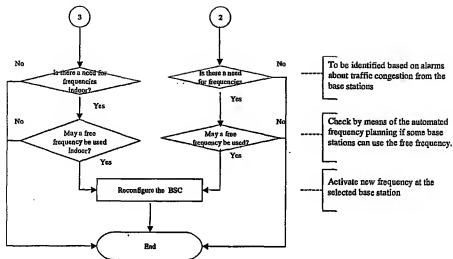
- 15 Scenario 3: Carrier frequencies are detected but are not in use by the radio network 2.

Diagram 2:



The handling when new carrier frequencies become available is depicted in the non-limiting example of the flowchart in diagram 3. The control server 7 decides whether it is necessary to use the available carrier frequency in those parts of the radio network 2 where it can be used. An automated frequency planning decides if it is possible to make use of the available frequency in the radio network 2 alongside the frequencies that are already used. If the control system decides to use the new frequency, the necessary reconfiguration of the base station controller 4 is initiated.

Diagram 3:



The handling of carrier frequencies which must be discontinued by the radio network 2 is depicted in the non-limiting example of the flow chart in diagram 4.

First the control system searches for a new frequency to replace the one to be discontinued. Information about available frequencies is stored in the control system and used with the automated frequency planning. Upon the decision to use a new carrier frequency, the control system will initiate the necessary reconfiguration of the base stations 5 via the base station controller 4.

Diagram 4:

